Biological Efficacy of Aqueous Extracts from Twelve Plants on the Moringa Defoliating Caterpillar (*Noorda blitealis* Walker, 1859)

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1 ABSTRACT

The systematic use of synthetic pesticides to control crop pests, such as moringa, *Moringa oleifera* Lam, (a leafy vegetable) raises concerns about poisoning in humans (both producers and consumers) and environmental pollution. Moringa is harvested every two weeks, whereas the pesticides used often have pre-harvest intervals (PHIs) exceeding 14 days. To minimize this risk, research into endogenous alternative solutions, such as the use of plant-based biopesticides, is necessary. In this context, 12 plants native to Niger were tested for their biological efficacy against the moringa defoliating caterpillar (*Noorda blitealis*). The tests were conducted in the laboratory using bioassays. Plant parts (leaves or seeds) were harvested, dried in the shade, and then ground into powder. The following concentrations, 0 g/L, 1 g/L, 10 g/L, 50 g/L, and 100 g/l were then applied on the second and third stage larvae. Larval mortality was observed 24 and 48 hours after exposure to the extracts. The results show that, for the LC50 values measured 48 hours after the start of the laboratory test, only 5 extracts plant extracts proved to be highly to moderately toxic to the pest (LC50 ≤ 10 g/L). These include *Ricinus communis* L. (leaves or seeds), *Azadirachta indica* A. Juss, *Lantana camara* L., and *Calotropis procera* (Aiton) W.T.Aiton. These plants, which possess insecticidal properties, may offer potential as alternatives to synthetic chemical pesticides in the control of *Noorda biltealis* and even other crop pests.

Efficacité biologique d'extraits aqueux de douze plantes sur la chenille défoliatrice du moringa (*Noorda blitealis* Walker, 1859)

RESUME

L'utilisation systématique de pesticides de synthèse pour lutter contre les ravageurs des cultures, comme le moringa, *Moringa oleifera* Lam (un légume-feuille), soulève des inquiétudes quant aux risques d'intoxication chez l'homme (tant chez les producteurs que chez les consommateurs) et à la pollution de l'environnement. Le moringa est récolté toutes les deux semaines, alors que les pesticides utilisés ont souvent des délais d'attente avant récolte (DAR) supérieurs à 14 jours. Afin de minimiser ce risque, il est nécessaire de mener des recherches sur des solutions alternatives endogènes, telles que l'utilisation de biopesticides d'origine végétale. Dans ce contexte, 12 plantes originaires du Niger ont été testées pour évaluer leur efficacité biologique contre la chenille défoliatrice du moringa (*Noorda blitealis*). Les tests ont été réalisés en laboratoire à l'aide de bio essais. Des parties de plantes (feuilles ou graines) ont été récoltées, séchées à l'ombre, puis réduites en poudre. Les concentrations de 0 g/l, 1 g/l, 10 g/l, 50 g/l et 100 g/l ont ensuite été appliquées sur des larves de deuxièmes et troisièmes stades. La mortalité larvaire a été

observée 24 et 48 heures après l'exposition aux extraits. Les résultats montrent que, pour les valeurs de CL_{50} mesurées 48 heures après le début de l'essai en laboratoire, seuls 5 extraits végétaux se sont révélés hautement à modérément toxiques pour le ravageur (CL_{50} ≤ 10 g/L). Il s'agit notamment de *Ricinus communis* L. (feuilles ou graines), d'*Azadirachta indica* A. Juss, de *Lantana camara* L. et de *Calotropis procera* (Aiton) W.T.Aiton. Ces plantes qui possèdent des propriétés insecticides, pourraient constituer des alternatives aux pesticides chimiques de synthèse pour lutter contre *Noorda biltealis*, voire d'autres ravageurs des cultures.

2 INTRODUCTION

In Niger, moringa is one of the main leafy vegetables, cultivated both under irrigation during the dry season and during the rainy season with supplemental irrigation. According to data from the Ministry of Agriculture, it is cultivated during the dry season on an area of 9,107.5 ha, with an annual production of approximately 240,000 metric tons, representing a national average yield of 26.30 metric tons per hectare (Sofreco, 2022). This yield is very low compared to the crop's potential. This low yield is due in part to heavy pest pressure from crop enemies, including pests (insects, mites, nematodes) and disease-causing agents (fungi, bacteria, and viruses). Several pests cause significant damage to moringa, both during the off-season and the rainy season. The main pests, in order of importance, are the defoliating caterpillar (*Noorda blitealis*) and the red spider mite (*Tetranychus urticae*). The most significant disease remains moringa dieback caused by the fungus *Botryodiplodia theobromae* (Haougui *et al.,* 2013; Haougui *et al.,* 2015). To minimize the impact of these pests and diseases on moringa production, farmers routinely use synthetic pesticides. This excessive reliance on synthetic pesticides is discouraged due to their harmful effects on human health and the environment, as well as the development of resistant strains of pests and pathogens (Lengai *et al.,* 2020). In this situation, the search for alternative control methods is the only viable option. Indeed, over the past two decades, botanical pesticides have gained particular importance. However, the use of plants with pesticidal properties dates back a very long time; since ancient times, plants or plant-derived minerals have been used to protect crops (Bibata *et al.,* 2023). These types of pesticides are effective in controlling various crop pests, can be produced by farmers theme-self, and have diverse modes of action. Their sources are readily available, and they are low in toxicity to non-target organisms. Their diverse modes of action are attributed to the phytochemical composition of different plants. They degrade rapidly and, with a few exceptions, are low in toxicity to mammals (Haougui *et al.,* 2021; (Texas-Agrilife, 2023). They can therefore be used in integrated pest management systems and contribute to sustainable agricultural production (Jamiołkowska and Kopacki, 2020). The first plants to be studied extensively were pyrethrum (*Pyrethrum anthemis*), tobacco (*Nicotiana tabacum*), derris (*Derris elliptica*), and neem (*Azadirachta indica*). From these plants, pyrethrins, nicotine, rotenone, and azadirachtin were extracted, respectively (Texas-AgriLife, 2023). Since then, however, research has intensified, and thousands of plants are being studied to identify their pesticidal properties. This is particularly noteworthy given that moringa is the most widely consumed leafy vegetable in Niger and is therefore most likely to pose a risk of chemical pesticide poisoning to consumers, considering the number of treatments and the quality of the products used (Bibata *et al.* 2026).The objective of this study was to evaluate the biological efficacy of 12 plants commonly found in Niger on populations of *Noorda blitealis* in the laboratory.

3 MATERIALS AND METHODS

3.1 Plant Material: This material consists of twelve (12) plants with biocidal properties. They were collected in three regions (Dosso, Diffa, and Niamey) but are found in all other regions of Niger, making them readily available to farmers. Table 1 provides a description of the plants studied. Plant parts (leaves or seeds) were collected in the urban commune of Niamey, with the exception of plants such as Hyptis suaveolens (Kalapaté-Dosso), *Leptanenia pyrotechnica, Pergularia tomentosa,* and *Calotropis procera* (Diffa). The plant specimens were identified by the INRAN plant ecology laboratory in Niamey, based on the Flora of Niger (INRAN, 2007).

Table 1: Description of the 12 Plants Used

Plants	Botanical family	Description
Calotropis procera (Aiton) W.T.Aiton, 1811	Asclepiadacea	Sodom apple tree, a shrub with round, apple-like fruit and white latex
Hyptis suaveolens (L.) Poit., 1806	Lamiaceae	A plant with oval leaves and purple flowers; it can grow up to 2 meters tall
Pergularia tomentosa L.	Apocynaceae	A shrub with white latex and thread-like stems
Ricinus comminus L., 1753	Euphorbiaceae	A tropical shrub with lobed or toothed leaves, growing 1 to 5 meters tall
Azadirachta indica A.Juss., 1830	Meliaceae	A tree native to Asia that was introduced to West Africa in the 1940s.
Leptadenia hastata (Pers.) Decne., 1844[1]	Apocynacea	A vine with oval, tapering leaves. Highly drought-tolerant
Leptadenia pyrotechnica (Forssk.) Decne., 1838	Apocynacea	A desert-zone shrub with needle-like leaves. It can grow to a height of 2 to 3 m
Cajanus cajan L., 1753	Fabaceae	A plant that can grow up to 4 m tall;
Ocimum basilicum L., 1753	Lamiaceae	A plant 20 to 60 cm tall, with oval leaves and small white flowers arranged in elongated clusters; it has a slightly spicy aroma
Lantana camara L., 1753	Verbenaceae	A plant 0.5 to 3 m tall, with a rectangular stem, opposite leaves, a spike-like inflorescence, and a drupe as its fruit
Balanites aegyptia (L.) Delile 1813	Zygophyllaceae	A thorny tree native to tropical savannas, with compound leaves consisting of two leaflets; the fruit is a drupe with sweet pulp
Datura inoxia Mill., 1768	Solanaceae	Commonly known as the prickly apple or jimson weed, it is abundant in all tropical and subtropical regions.

3.2 Animal Material: The animal material consisted of second and third-stage larvae (L2 and L3) of *Noorda blitealis*, reared at the Plant Protection Laboratory of the Regional Agricultural Research Center (CERRA) in Niamey.

3.3 Bioassay Procedure: Plant parts (leaves or seeds) were first dried in the shade at room temperature in the laboratory for one week to 10 days, depending on the species. They were then ground into a powder using a blender with metal blades. The resulting powder was subsequently sieved through a fine-mesh sieve. The extracts were prepared from a standard suspension, or stock solution, obtained by adding 100 g of the powder from each plant to one liter of distilled water. This mixture was left to macerate for 24 hours at room temperature in the laboratory. After filtration using Whatman No. 1 filter paper, each preparation was stored in the refrigerator at 4°C. To obtain the various concentrations, successive dilutions were made from the stock solution. Ultimately, the following concentrations were selected: C0 = 0 g/L, C1 = 100 g/L, C2 = 50 g/L, C3 = 10 g/L, C4 = 1 g/L, C5 = 0.1 g/L.

The tests were conducted according to the standard method (IRD et Mivegec, 2021), in which mortality is considered significant if it is greater than or equal to 80%. The experiment was carried out using Petri dishes for each extract. To do this, 10 grams of moringa leaves freshly picked from the garden of the Niamey Regional Agricultural Research Center (CERRA/Niamey) were soaked for 5 seconds in the aqueous extract at the specified concentration; they were then placed at the bottom of the Petri dish. Next, 10 second- or third-instar larvae (L2 or L3) were placed on the treated leaves. For each concentration, three replicates were used, for a total of 30 larvae (L2 or L3) per concentration of the extract in question. Twenty-four (24) and forty-eight (48) hours after the start of the experiment, larval mortality was recorded, and the actual mortality percentage was calculated using the World Health Organization bioassay protocol formula (WHO, 2006):

$$\text{Mortality} = \frac{\text{number of dead larvae}}{\text{number of larvae introduced}} x\ 100$$

The crude mortality rates were then adjusted using Abbott's (1925) formula, as shown in Equation

$$\text{Adjusted mortality} = \frac{\text{mortality of treated larvae} - \text{mortality of the control}}{100 - \text{mortality of the control}} x\ 100$$

3.4 Data Analysis: The data were entered into an Excel spreadsheet, and mortality trend lines were plotted along with their equations. To determine a product's efficacy, the half-lethal concentration (LC_{50}) was calculated. This is the concentration that would kill 50% of a population of larvae exposed to the product. This parameter was interpreted using the scientific LC_{50} rating scale for dip tests developed by Wang *et al.* (2025). This scale is divided into three classes. LC_{50} less than 1 g/L = highly toxic; LC_{50} between 1 and 2 = toxic; LC_{50} between 2 and 10 g/L = moderately toxic; and LC_{50} greater than 10 g/L = non-toxic (ineffective). This scale was modified by adding an intermediate class between 1 and 2. Statistical analysis was performed using analysis of variance (ANOVA), supplemented by the LSD (5%) test for comparing means, using Statistics 10 software.

4 RESULTS

In tests conducted on L2 larvae, five (5) plants showed an efficacy of less than 80% according to WHO standards (2011). These were basil (*Ocimum basilicum*), stramonium (*Datura inoxia*), *Leptadenia hastata, Leptadenia pyrotechnica,* and *Balanites aegyptiaca*. For L3 larvae, aside from these plants, two others were ineffective: pigeon pea (*Cajanus cajan*) and Pergularia tomentosa. The plants that showed some efficacies were castor bean (*R. communis*) (leaves and seeds), neem (*Azadirachta indica*), lantana (Lantana camara), and Calotropis procera. They exhibited LC50 values less than or equal to 10 g/l for both L2 and L3 larvae after 48 hours of exposure.

4.1 Effect of Treatments on Second-Stage (L2) Larvae of *N. blitealis*: The response of N. blitealis L2 larvae is shown in Figure 2. The results presented here are those for plants in which mortality was 80% or higher at the highest concentration 48 hours after the larvae were first exposed to the products. Thus, basil (*Ocimum basilicum*), stramonium (*Datura inoxia*), *Leptadenia hastata, L. pyrotechnica,* and *Balanites aegyptiaca* were not included in the analyses. The pigeon pea (*Cajanus cajan*) had a mortality rate of less than 80% at the highest concentration within 24 hours; however, this mortality rate exceeded that threshold over the course of 48 hours. It was therefore selected for determining the 50% effective concentration. For the other plants (including the pigeon pea), the trend curves follow a logarithmic pattern. In general, larval mortality is positively correlated with the product concentration (Fig. 1).

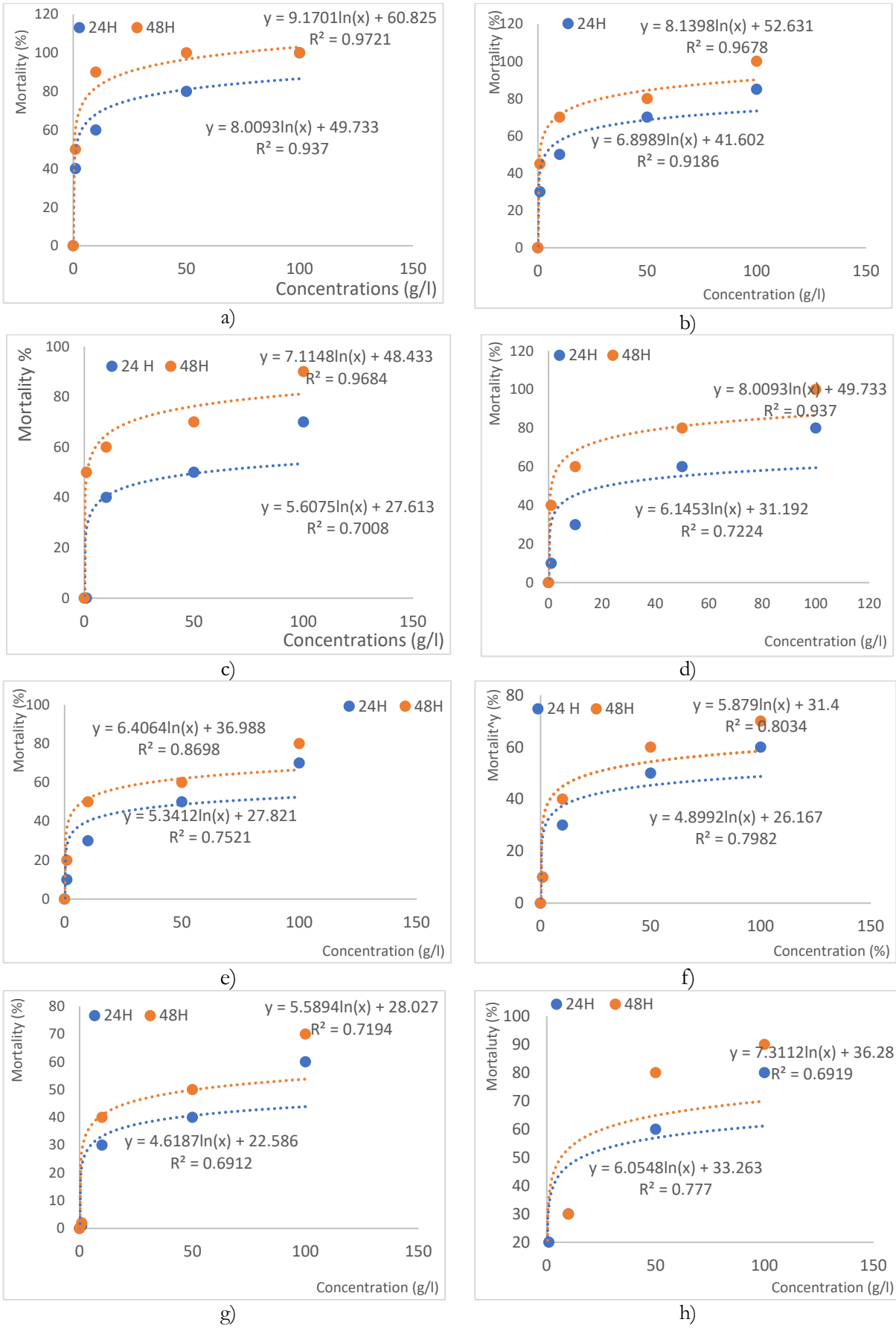


Figure 1: Relationship between L2 larval mortality and the concentration of a) *Ricinus communis* (seed), b) *Ricinus communis* (leaf), c) *Lantana camara*, d) *Azadirachta indica*, e) *Hyptis suaveolens,* f) *Pergularia tomentosa*, g) *Cajanus cajan*, and h) *Calotropis procera.*

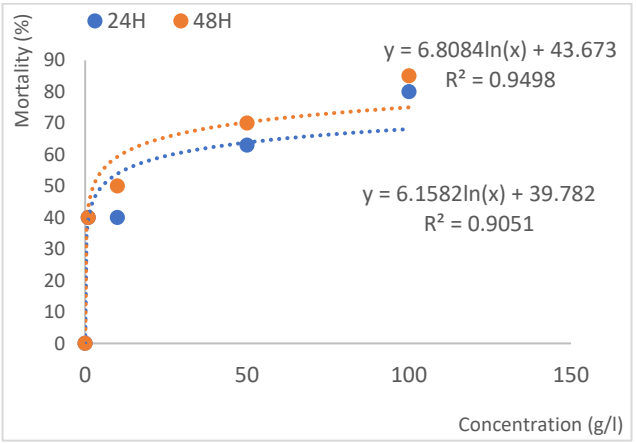
The half-maximal lethal concentrations (LC_{50}) calculated from the trend line equations are shown in Table 2.

Table 2: Variation in half-maximal lethal concentrations (LC_{50}) on L2 as a function of treatment. Numbers in the same column followed by the same letter are not significantly different.

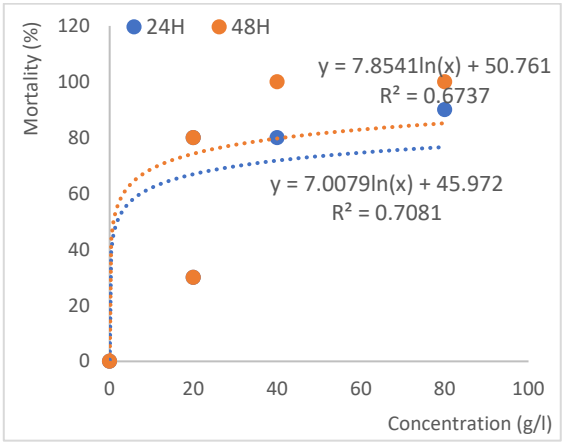
Aqueous Plant Extracts	LC50(g/l)	
	24 H	48 H
Ricinus communis (leaves)	3.35d	0.73cd
Ricinus communis(grain)	1.03d	0.31d
Hyptis suaveolens	63.43c	7.61b
Calotropis procera	15.80d	6,49b
Azadirachta indica	21.33d	1.28c
Cajanus cajan	379.00a	28.79 a
Pergularia tomentosa	130.32b	23.57a
Lantana camara	54.05 c	1.25c
P. value	P=0.0030	0.0004

After 24 hours (Table 2) of exposure to plant solutions, the lowest LC_{50} values were obtained with R. communis seeds (1.03 g/l), followed by *R. communis* leaves (3.35 g/l). The highest LC_{50} value was obtained with *Cajanus cajan* (379 g/L). The most toxic extract was that from *R. communis* seeds (Class 1), and the toxic extract was that from *R. communis* leaves. All others were non-toxic (LC_{50} > 10 g/l). After 48 hours (Table 2) of exposure to the aqueous extracts, the same trend persisted, with pronounced efficacy for all plants. With the exception of *Cajanus cajan* and Pergularia tomentosa, all extracts had LC_{50} values below 10 g/L. The lowest LC_{50} values were consistently observed for castor bean (seeds and leaves), followed by neem and *Lantana camara*. Based on the toxicity index (Table 2), three groups were identified: Group 1, for which the LC50 is less than 2 g/L (castor bean seeds, castor bean leaves, *Azadirachta indica*, and *Lantana camara*). Group 2 (IC50 between 2 and 10 g/L), which includes *Hyptis suaveolens* and *Calotropis procera*, and Group 3 (IC50 greater than 10 g/L), which includes *Pergularia tomentosa* and *Cajanus cajan*.:

4.2 Effect of Treatments on Third-Stage (L3) larvae of *N. blitealis:* As with L2 larvae, extracts from the following plants showed an efficacy of less than 80% at the highest concentration (100 g/L). *Pergularia tomentosa* and *Cajanus cajan* were added to the list of plants that were not very effective against L2 larvae. Only 6 plants showed some efficacy against L3 larvae, at least after 48 hours of exposure (Figure 3).



a)



b)

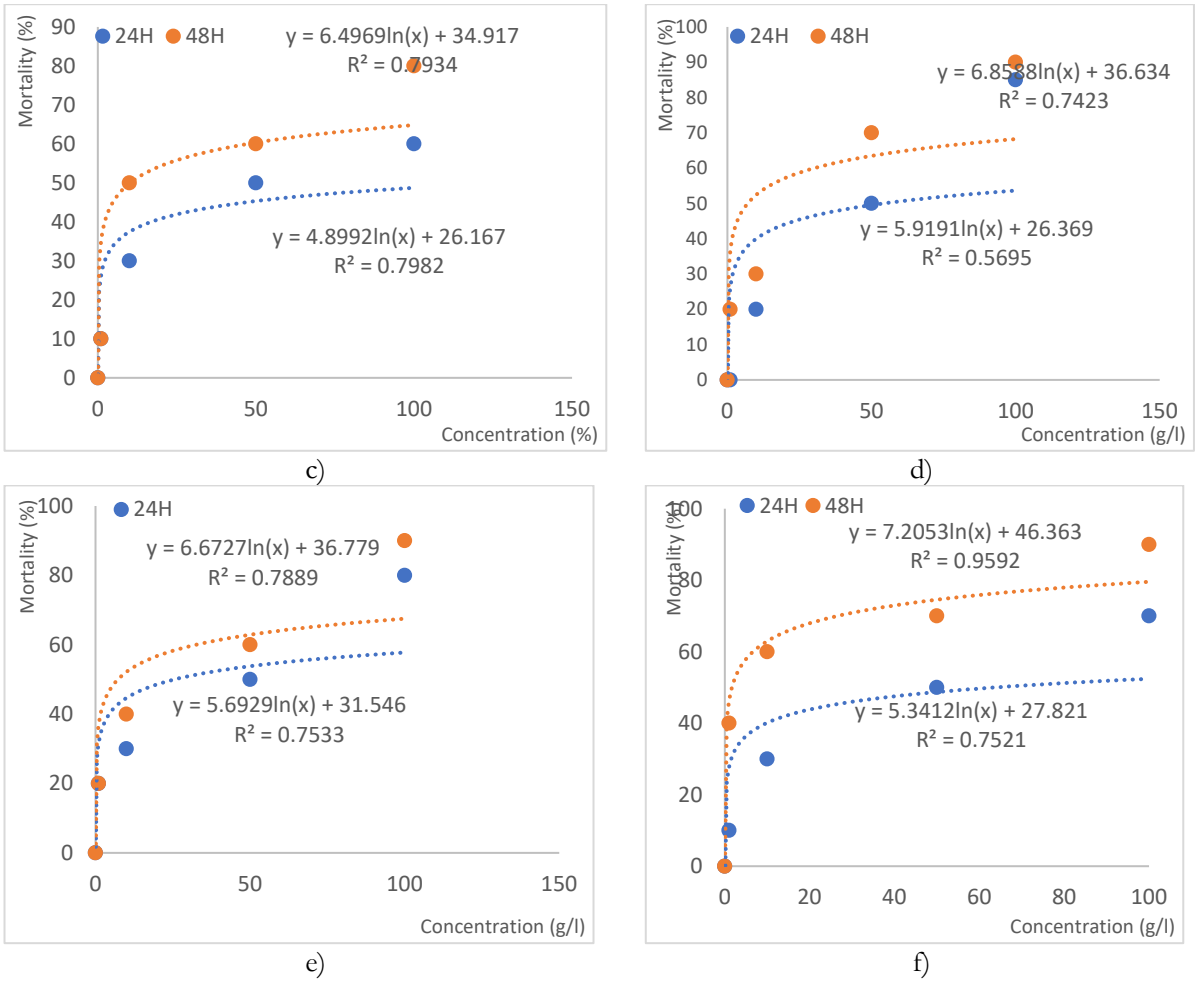


Figure 2: Relationship between L3 larval mortality and the concentration of a) *Ricinus communis* (seed), b) *Ricinus communis* (leaf), c) *Hyptis suaveolens*, d) *Calotropis procera*, e) *Azadirachta indica*, and f) *Lantana camara.*

After 24 hours of exposure, the calculated 50% lethal concentrations (LC50) are listed in Table 3. The results show that the lowest LC50 was obtained for castor beans (1.77 g/L), and the highest for *Hyptis suaveolens* (129.02 g/l). Castor beans are classified in Group 2 with an LC_{50} of 1.77 g/l. Next are castor bean leaves in Group 3 with an LC_{50} of 5.26 g/L. All other plants are grouped in Group 4, which has very low toxicity.

Table 3: variation in 50% lethal concentrations (LC50) on L3 as a function of treatment. Numbers in the same column followed by the same letter are not significantly different.

Aqueous plant extracts	**LC50**	
	24 H	**48 H**
Ricinus comminus (feuille)	5.26d	2.53b
Ricinus comminus (grain)	1.77^{e}	0.91c
Lantana camara	63.43b	1.66bc
Hyptis suaveolens	129.02 a	10.18a
Calotropis procera	54.05 b	7.03a
Azadirachta indica	25.53c	7.24a
P values	P=0.0012	P=0.0004

After 48 hours of exposure, the LC50 values ranged from 0.91 g/L for castor beans to 10.18 g/l for Hyptis suaveolens. Virtually all extracts fall into Group 1, with a very slight exception for H. suaveolens. The aqueous extracts of castor beans were highly toxic (LC50), whereas all other products exhibited moderate toxicity (LC50 > 10 g/l). The overall results show that, for both L2 and L3, the LC50 values obtained after 24 hours are higher than those recorded after 48 hours of exposure (Tables 1 and 2).

5 DISCUSSION

The study of the biological efficacy of the aqueous extracts of the 12 selected plants shows that the LC50 values of the so-called effective products ranged from 0.31 g/l for castor beans to 7.61 g/l for *H. suaveolens* over 48 hours on L2; in contrast, they ranged from 0.91 g/l for castor beans to 10.18 g/l for *H. suaveolens* on L3, which were thus higher than the initial values. In toxicology, the lower the LC_{50}, the more toxic the product is to the target (Chikwana, 2023). In all cases, castor bean seed extracts were highly toxic, with LC50 values <1 g/l. These were followed by castor bean leaf extracts, whose LC50 values ranged from 0.73 g/l (after 48 hours on L2) to 2.5 g/l after 48 hours on L3. Castor bean (*Ricinus communis*) is known to be effective against several other pests, both in major tropical crops such as cowpea and in vegetable crops (Agbobatinkpo *et al.,* 2018; Badinengantyi *et al.,* 2023). Evaluations of the larvicidal activity of aqueous extracts from castor bean leaves have demonstrated the plant's effectiveness in controlling mosquitoes that transmit *Plasmodium* (Aouinty *et al.,* 2006; Shyamapada, 2010; Asaad et and Basheer, 2014; Aouinty *et al.,* 2018). Shing and Kaur (2016) reported that aqueous extracts of castor bean leaves are effective against houseflies in homes. The effect of castor bean is due to its high content of alkaloids, including ricin, a highly toxic glycoprotein, and cyanine, a compound from which hydrogen cyanide is derived (Dumeignil, 2012). In addition, Sreenivasa *et al.* (2012) observed, through a qualitative analysis of the extracts for various photochemical compounds, the presence of terpenoids, steroids, flavonoids, tannins, and saponins in the leaf extracts. Neem leaves exhibited LC_{50} values greater than 10 g/l after 24 hours of exposure for both L2 and L3. However, after 48 hours, their LC_{50} values were 1.28 g/l for L2 and 7.24 g/l for both L2 and L3. This classifies them as toxic to moderately toxic. The insecticidal properties of neem seeds (*Azadirachta indica*) against the defoliating caterpillar (*Noorda blitealis*) were tested in Niger by Moumouni and Mahamane (2021), who reported a larval mortality rate of 90%. Halilou and Doumma (2023) achieved L3 larval mortality rates of 80% and 96% using commercial formulations of neem seeds (EAGN) and neem oil (SHN) after 96 hours of exposure at concentrations of 80 g/l and 8 ml/l, respectively. Various insect pests are known to be susceptible to aqueous neem extracts (Thomas-Odjo *et al.,* 2010; Garba *et al.,* 2017; Bello *et al.,* 2019; Agbo *et al.,* 2019; Ouédraogo *et al.,* 2021; Pierre *et al.,* 2021). According to Mondal and Mondal (2012), it has been tested on nearly 550 species of insect pests and vectors of human diseases worldwide. Garba et al. (2017) tested it against the tomato leafminer, *Tuta absoluta*, a new invasive pest of the Solanaceous family in general and tomatoes in particular. Most recently, Zohoungbogbo *et al.* (2024) used neem to control virus-carrying insects on cowpeas in Benin. But a year earlier, Keita *et al.* (2023) demonstrated that aqueous extracts of this plant effectively control fruit flies of the genera *Ceratitis* and *Bactrocera*. In Senegal, Sané et al. (2018) reported the use of neem-based products against sucking pests and phytophagous caterpillars of cotton. Its best-known active ingredient is azadirachtin (Spyrou *et al.,* 2009; Diedhiou *et al.,* 2015; Aribi *et al.,* 2020; Zain *et al.,* 2022). Neem has even been used against *Plasmodium* vector insects, where it has proven highly effective, and has been incorporated into malaria control programs in the tropics (Carnevale, 2017). *Lantana camara* exhibited LC_{50} values of 1.66 and 1.25 g/l on second- and third-stage larvae, respectively, after 48 hours of exposure. This places extracts from this plant in toxicity group 2 with respect

to the moringa defoliating caterpillar. *Lantana camara* is also used in traditional medicine to treat intestinal worms (Jitendra *et al.,* 2011) and to combat malaria by targeting mosquito vectors (Abd-el *et al.,* 2019; Dua *et al.,* 2003; Enda *et al.,* 2020). The active compounds against insect pests are essential oils, the main ones being caryophyllene, isoledene, and α-copaene (Kolapparamban, 2024). *Calotropis procera* exhibited low LC_{50} values for both L2 and L3 after 48 hours of exposure. For L2, the LC_{50} value was 6.49 g/l, compared to 7.03 g/l for L3. This classifies it as a moderately toxic plant. This plant has been shown to be effective against several insect pests. According to Bakavathiappan *et al.* (2012), aqueous extracts of this plant are effective against the third larval stage of *Spodoptera litura* in corn crops. Similarly, Khan and Dewanda (2017) demonstrated that the active compounds contained in the organs of *C. procera* have a repellent effect on the larvae of the cabbage moth, *Plutella xylostella*, and help reduce infestations in the field. The insecticidal properties of this plant are due to the presence of phenolic compounds, alkaloids, and steroids in its latex (Cavalcante *et al.,* 2020; Mazen *et al.,* 2020).

6 CONCLUSION

The study demonstrated that aqueous extracts from four plants (*Ricinus communis, Azadirachta indica, Lantana camara* and *Caloropis procera*) are effective against the moringa defoliating caterpillar (*Noorda blitealis*) in laboratory tests. It would be worthwhile to continue this research at experimental stations and in real-world conditions to confirm these results. The goal is to use these extracts as alternatives to chemical pest control using synthetic pesticides, thereby reducing risks to humans, animals, and the environment. Today, botanical (plant-based) biopesticides have become very popular due to their biodegradability, low persistence, and low toxicity to non-target organisms, as well as their affordability and ease of access.

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